BEHAVIOUR OF CABLE-STAYED BRIDGE WITH CABLE LOSSES

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Engineering in Civil Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotation and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

Progressive collapse have always been a serious threat to cable-stayed bridge, and has historically caused vast demolition of man-made structure and loss of lives. It is a kind of structural failure, which caused by breakdown of a particular structural part and the incapability of the structural system to cope with the disruption of force. A chain reaction will be generated, causing the destruction of the whole bridge structure. In this research, the structural performance of a cable-stayed bridge under cable failure has been studied.

This research demonstrate the modelling and analysis of the simplified and modified Penang Second Bridge using SAP2000. This work study the performance of cable-stayed bridge with and without loaded of the static vehicle. This work was also examine the structural response of the cable-stayed bridge to the loss of cables. The progressive collapse analysis has done by removing the cables and checking their effect on the cable axial force.

ABSTRAK

Keruntuhan progresif adalah ancaman terhadap jambatan kabel. Masalah ini telah banyak memusnahkan harta benda dan meragut nyawa manusia. Keruntuhan progresif adalah disebabkan oleh kegagalan struktur. Bahagian struktur jambatan yang gagal akan menyebabkan kemusnahan sistem struktur dan keruntuhan seluruh struktur jambatan. Dalam kajian ini, reaksi struktur jambatan kabel atas kegagalan kabel telah diuji.

Kajian ini menunjukkan pemodelan dan analisis Jambatan Kedua Pulau Pinang yang dipermudahkan dan diubahsuai dengan menggunakan SAP2000. Kajian ini menguji reaksi jambatan kabel atas kemuatan kenderaan statik. Kerja-kerja ini juga akan mengkaji tindak balas struktur jambatan kabel atas kehilangan kabel. Analisis keruntuhan progresif akan dilakukan dengan mengeluarkan kabel dan memeriksa kesannya pada daya paksi kabel.

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INTRODUCTION

1.1 Project Background

A bridge is built to provide passage over the obstacle. It comes with a different design when encountered with a different situation. Each of them has their particular purpose and function. The cable-stayed bridge is a bridge where its cable holds the deck by connecting it directly to the towers. The cables usually come in four kind of designs, which are the harp, fan, mono and star. A semi-fan or semi-harp design is usually preferred as it is more practical especially when many cables are involved. There is also four kinds of column arrangement among the cable-stayed bridge design, which is single, double, portal and A-shaped.

Cable-stayed bridges are first found in 1595, where the designs were found in Machinae Novae, a book by Venetian inventor Fausto Veranzio (X.Niu, 2013). Many suspension bridge at early were similar to the cable-stayed. The designers are then found that cable-stayed bridge is stiffer and more economic. Construction of this type of bridge continued into the 20th century where modern concrete stayed bridges with concrete or steel decked were built (J.Niels, 1999). Today the concrete stayed bridge can be built in different varieties and types.

There is always a confusion between a suspension bridge and a cable-stayed bridge. At first glance, these two bridge are looking alike, but there is a difference between their construction and principle. In suspension bridges, there are large main cables which anchored to the ground hanging between the pylons. It bears the load of the bridge deck. The tension of the main cables is then transferred to the ground at the anchorages. The forces within the bridge are shown in Figure1.1.

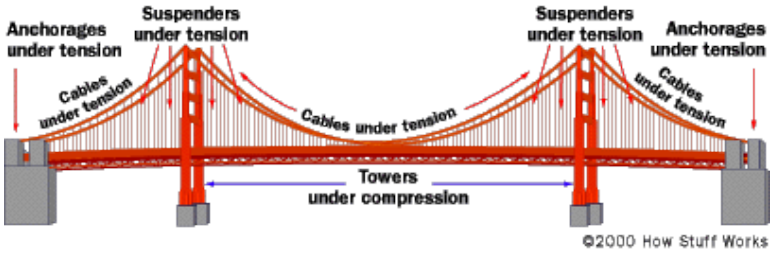

Figure 1.1 Forces within suspension bridge

(Robert Lamb, Michael Morrissey, 2000)

Cable-stayed bridges also have the towers and decks which held by cables, but the deck are connected directly to the towers through cables. For the deck near the towers, cantilevers are used to support their weight. Cable-stayed bridge requires stronger bridge deck to resist the horizontal compression loads. Figure 1.2 shows the force within the cable-stayed bridge.

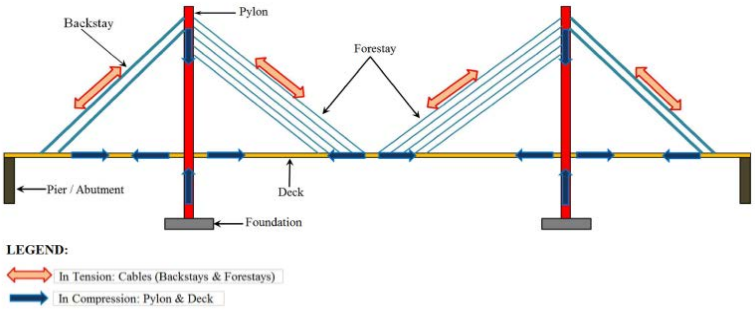

Figure 1.2 Forces within a cable-stayed bridge system

(M Khairussaleh, A Nor, 2016)

In a cable-stayed bridge, the forces are exerted on all the main parts, which are the cables, pylons and the deck. The weight of the deck is held by the cables, making it stretched and in tension. The pylons are under compression of both the weight of cables and deck. The deck is under both compression and tension as the top of the deck is stretched to tension condition while its bottom being compressed.

1.2 Problem Statement

Since cable-stayed bridge have been introduced, this type of bridge has been known for its stiff structure. However, failures are still happening, resulting in massive loss of money and materials. Some bridge failure will even cause life loss. The study of the past failure incident is essential for us to enhance the construction method and bridge design.

One of the causes of these damages is the failure in a number of elements during ultimate events such as an earthquake or severe wind. In these types of failures, earthquake or wind act as primary perturbation factors which propagate the local failure within the structure. They are natural disasters which are unavoidable Unpredictable events like terrorist attacks and vehicle collision also cause failure in some elements due to loading beyond the capacity. The failure of the bridge can be prevented with a proper design and quality control. A lot of variation has to be taken into consideration when a bridge is designed. The failure of any structural element should be measured as a possible local failure for cable stayed bridges will lead to low resistances against accidental lateral loads from vehicle impact or accidental actions. The loss of cables can lead to overloading and rupture of adjacent cables.

In a cable-stayed bridge, each cable is bearing with different loading depending on where it is installed. When failures occurred, progressive collapse tends to happen in a cable-stayed bridge. The loss of cables must be considered as a possible local failure since the cross sections of cables are usually small, and therefore provide low resistances against accidental lateral loads stemming from vehicle impact or malicious action (Buscemi, N., Marjanishvili, S.,2005).

The loss of cables can lead to overloading and rupture of adjacent cables. Furthermore, the stiffening girder is in compression and a cable loss reduces its bracing against buckling (Buscemi, N., Marjanishvili, S.,2005).

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